DEVELOPING PRECON™, A DECONTAMINATION-AID COATING

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ABSTRACT

In a SBIR project funded through the Naval Air Warfare Center (contract N68335-00-C-0326), TDA Research has developed a new coating product to aid in chemical defense. The water-based coating is applied to substrates prior to exposure to chemical agents and facilitates decontamination with a simple water wash should the coated substrates become contaminated. The coating is inexpensive, non-corrosive, non-flammable, and easy to use. When applied to cloth, it does not alter the water-vapor permeation rate through the fabric. After rinsing, coated cloth samples retained less than 1% of the applied GB or HD contamination, whereas uncoatd cloth samples retained more than 40% of the applied agent HD even when treated with the oxidizing Sandia foam.

INTRODUCTION

The U.S. military has a foreseeable need to restore and continue operations in a chemically contaminated battlespace. One potential limitation for these continuing operations is a supply of clean, non-contaminated materiel for the fighting personnel to use and wear. Of particular concern to our sponsors in the Naval Air Warfare Center was the logistics burden associated with replacing the aircrew ensemble for every airman after every sortie in a contaminated battlespace. We therefore sought to develop a coating that would allow rapid, safe decontamination and reuse of equipment exposed to chemical contamination.

Specifically, the water-based coating prevents chemical agents from diffusing into coated equipment and allows decontamination by simply rinsing with water. Ideally, it would be very inexpensive, optically clear, thin, flexible, and safe to use. To our knowledge, this sort of prophylactic approach toward decontamination has not been previously attempted.

In this paper, we summarize the features and performance of Precon™, the decontamination-aid coating developed at TDA Research, Inc.

COATING FEATURES

We formulated Precon™ with commercially available ingredients, making it inexpensive to produce. We have successfully packaged the coating both in a single component aerosol and in a

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simple hand operated spray bottle. To apply the coating, it is simply sprayed onto the substrate from a distance of about 2-3 feet, as shown in
Figure 2, until the substrate looks wet but is not yet saturated with the liquid coating formulation. The coating then dries on the substrate and dries to a loading of about 0.05 kg/m^2.

To make it easy to use, we formulated Precon™ with surfactants that produce foam when the coating is rinsed (see

Figure 1), removing both contamination and coating from the substrate. In practice, the substrate will be rinsed until the foam production diminishes, which indicates that the coating and the contamination have been removed. In practice, for a full aircrew ensemble, removing the coating and contamination will require several minutes of rinsing.

Precon™ is safe to use. In the ASTM test for flammability of fabrics (ASTM F1358), coated Nomex cloth is no more flammable than uncoated Nomex. Based *in vitro* eye and skin irritation tests conducted by InVitro International (Irritection assay, Irvine, CA), the formulation is classified as a borderline mild irritant/non-irritant to the skin and eyes. Precon™ also does not

contribute significantly to heat stress, since coated cloth items retain their water vapor permeability as shown in Figure 3.

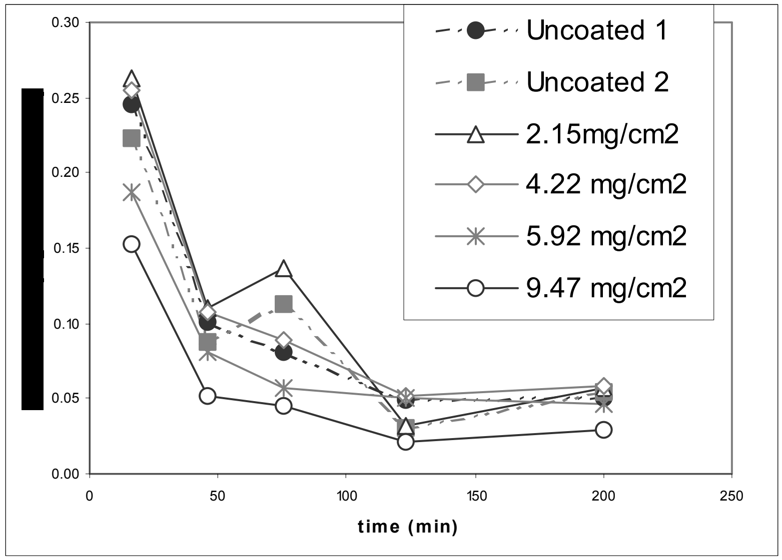

Figure 1. Image of the foam generated by rinsing Precon™ with water

Figure 2. Aerosol application of Precon™.

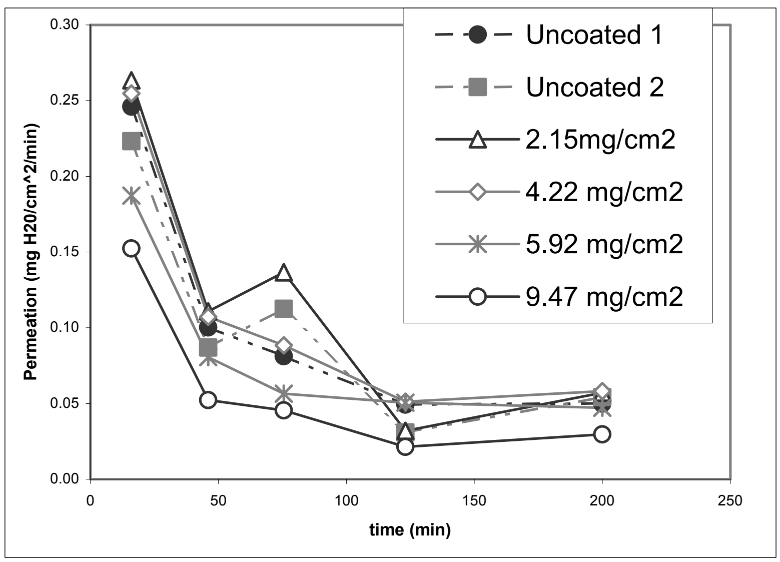

Figure 3. Water vapor permeability of Nomex cloth as a function of coating application density. A typical coating density is 4-5 mg/cm^2.

COATING PERFORMANCE

Testing the coating performance against chemical agents and simulants consisted of contaminating the 4 cm diameter Nomex coupons with an aerosol of the agent (ca. 10 g/m^2), storing the contaminated coupons in a small glass vial or petri dish for 1 hour, rinsing each with a controlled amount of water, then extracting the remaining agent from the coupons and quantifying by gas chromatography. Both the aerosol agent delivery device and the rinsing apparatus were mechanized to remove operator bias in contamination and rinsing procedures.

Agent aerosol was applied by atomizing an aliquot of the agent through a glass aspirator of the type commonly used to coat silica sheets for thin layer chromatography. In operation, house air at 100 psig was fed to a regulator at the beginning of the system where the pressure was reduced to approximately 6 psig. The air stream is split at this point to supply the aspirator with

air for atomizing and entraining the agent or simulant. The airflow could be stopped by means of a ball valve (V-1, in **Error! Not a valid bookmark self-reference.**). The air stream exiting the regulator is also fed to a three way valve (3WV-1) where the air is either used to pressurize the sample reservoir containing the agent or simulant, or directed as carrier gas to the sampling valve (SV-1). When the sample reservoir was pressurized, the flowrate of simulant or agent could be controlled using the Teflon needle valve (NV-1) between the reservoir and the sampling valve. Once the chemical entered the sampling valve, it either filled the sample loop or went directly to the waste reservoir, depending on the position of the sampling valve.

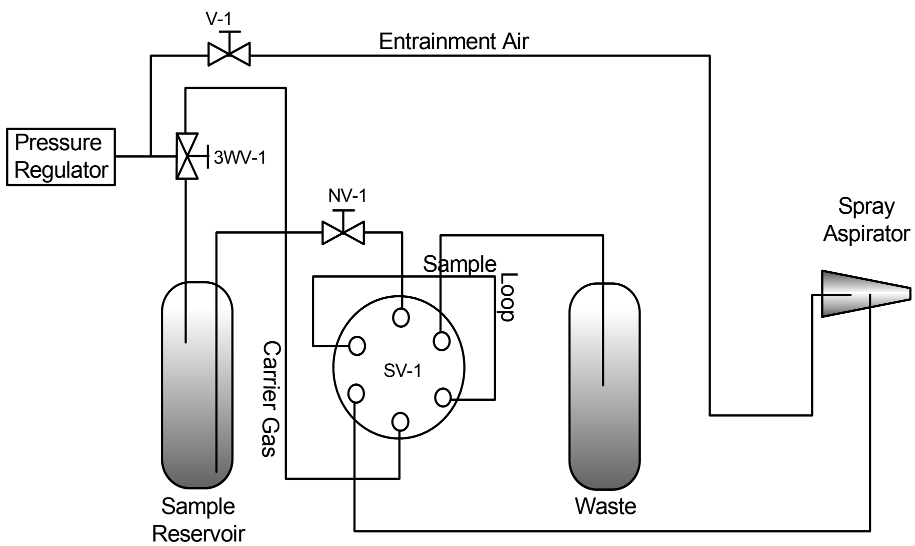

Figure 4. Diagram of chemical warfare agent atomizer.

During a typical experiment, once the sample loop has filled, the needle valve is closed to prevent excessive use of the warfare agent or simulant. The operator then actuates ball valve V-1, initiating the flow of entrainment air through the aspirator, and then subsequently actuates the three way valve, 3WV-1, redirecting air through the sample valve as carrier gas. By actuating the sampling valve, SV-1, the simulant is then swept out of the sample loop, and to the spray aspirator where it is atomized into a mist and deposited on the substrate placed in the target area. To prevent excessive evaporation of the deposited simulant, the operator then immediately shuts off the entrainment air by returning V-1 to its original position and closing 3WV-1. Contaminant loading, measured gravimetrically, was typically reproducible to within 10%.

Since, ideally, the aircrew ensemble is to be decontaminated by washing with a hose, TDA has designed and assembled an apparatus to simulate this washing procedure in a controlled environment. To test coating effectiveness, automated reproducible washing was critical to avoid unintentional operator bias. In fact, reproducible sample washing was the biggest single source of uncertainty in the entire analytical procedure to determine the relative effectiveness of various coating formulations. The washing apparatus, pictured schematically in Figure 4, allows for a fixed

volume of water to be sprayed onto the sample material at a fixed pressure (or rate). The wash volume is metered into a pressure vessel from a graduated 1 L buret. The pressure vessel is then pressurized with house air to typically 20 psig. Finally, the water in the pressure vessel is sprayed onto the sample material by a small nozzle. During spraying, the water pressure is maintained by means of an air ballast tank. The rinse water, containing the coating solution and some residual CEES is drained from the apparatus and collected for proper chemical disposal.

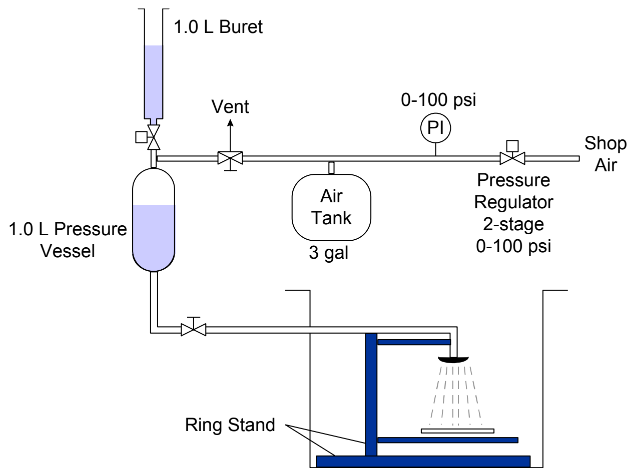

Figure 4. Automated sample washing apparatus.

We developed the coating in our laboratories, using a chemical agent simulant, chloroethyl ethyl sulfide (CEES), as a surrogate for live agents. **Figure 5** shows the fraction of a chemical agent simulant, chloroethyl ethyl sulfide (CEES), remaining on coated and uncoated (blank) Nomex coupons for samples tested the day after the coating was applied. Samples were stored for 1 hour between contamination and rinsing. Both the second and fourth samples were treated for five minutes immediately before rinsing with twice the manufacturer's recommended dose of oxidizing Sandia foam (Modec, Inc.). After the coating dries, it is effective indefinitely. For coated items stored since they were coated, we have demonstrated that efficacy does not diminish in three months. We do not yet have data, however, on the expected lifetime of the coating on a substrate in daily use.

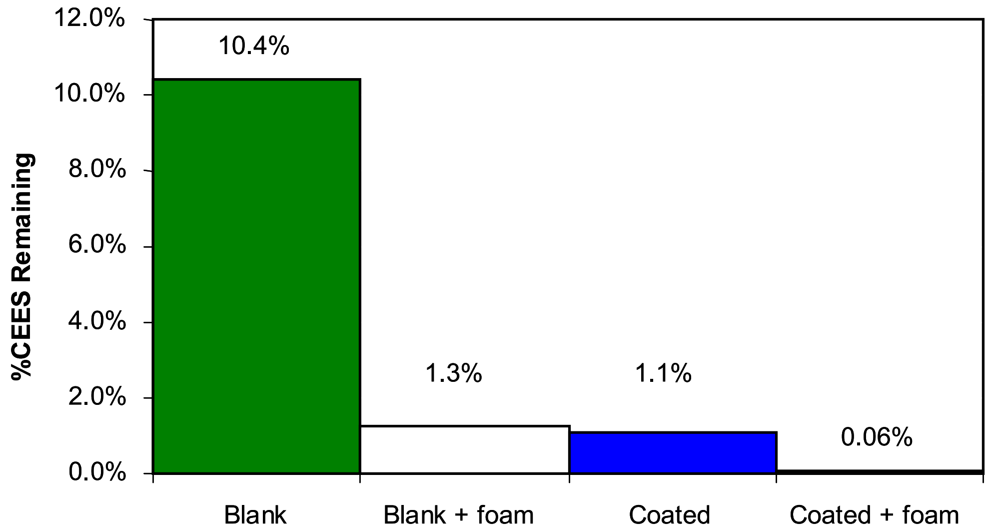

Figure 5. Fraction of CEES remaining after rinsing for coated and uncoated Nomex samples both treated and untreated with Sandia foam.

When the coating formulation was complete, we sent coated and blank Nomex samples to the Calspan/University of Buffalo Research Center (CUBRC) for live agent testing. Figure 6 shows the results with sulfur mustard, agent HD. Clearly, agent HD is much less water soluble than CEES and does not rinse off of uncoated coupons. The Sandia foam is not particularly effective at reducing the level of mustard contamination, reducing the percentage of recovered agent from 69% (untreated) to only about 40% of the nominal 10 g/m^2 contamination. In contrast, the precoated samples retained less than 1% of the applied HD aerosol after rinsing, and the cleanliness of the coupons was not significantly improved by the application of oxidizing foam before rinsing.

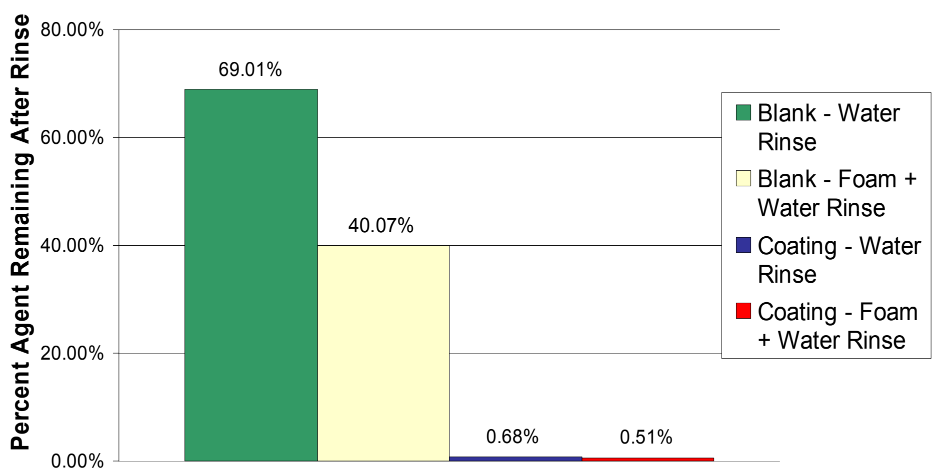

Figure 6. Percent of sulfur mustard (agent HD) remaining after rinsing.

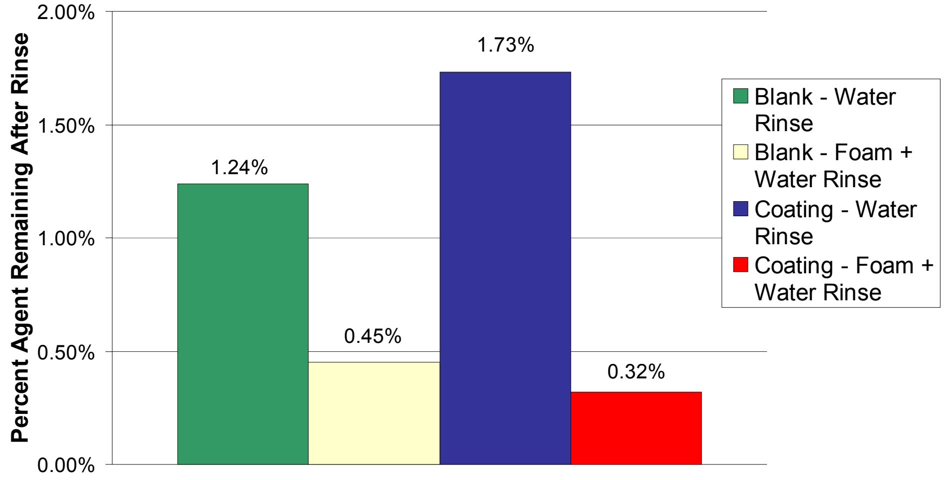

Figure 7. Percent of agent VX remaining after rinsing.

Figure 7 shows the results from testing with agent VX. VX is moderately water soluble, and a simple water rinse removes almost 99% of the agent from even untreated Nomex. The Sandia foam treatment (5 minutes at twice the manufacturer's recommended dose) significantly reduces the residual VX contamination, whether or not the samples were pretreated with the coating. This data clearly shows that Precon™ is not particularly effective against agent VX, but it does not inhibit the detoxifying effects of oxidizing decontaminants.

The G-agents are readily detoxified by water and are somewhat soluble, so the removal of better than 99.9% of the applied agent GB (sarin) with a water rinse is not surprising. Application of Precon™ allows contamination removal nearly to the 5X level (99.999%). We did not test Precon™ in conjunction with the Sandia foam against GB.

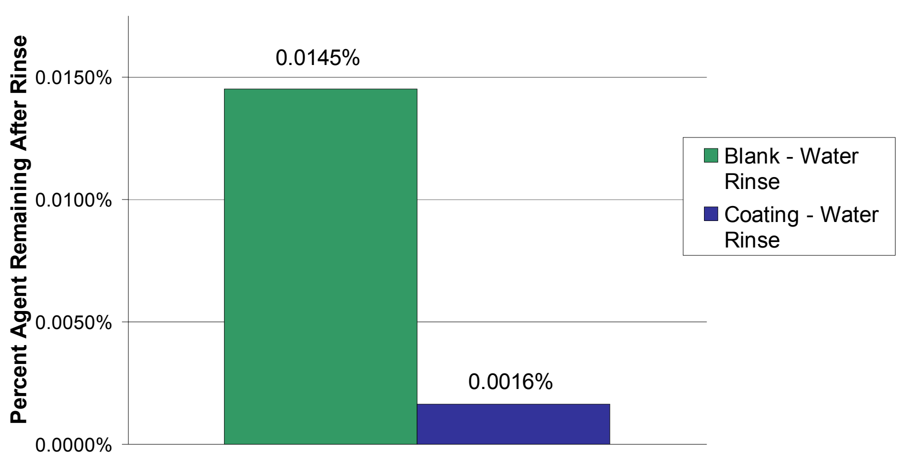

Figure 8. Percent of agent GB remaining after rinsing

COATING LIMITATIONS

During our formulation efforts, we have noticed that the coating formulation has several limitations that may be important for particular applications. While colorless, the coating does

not dry optically clear and is therefore not suitable for application onto optical surfaces such as visors or night vision goggles. In very humid environments (e.g. r.h.>90%), the coating can feel slightly tacky on non-porous substrates, and it may not therefore be well suited to jungle environments. This tackiness can be reduced at the expense of decreased efficacy against chemical agents. Finally, since the coating is designed to rinse off with the chemical contamination, the coating must be reapplied after rinsing or laundering.

CONCLUSIONS

In a SBIR research and development project, TDA Research has formulated an inexpensive water based coating that provides protection of coated equipment from contamination by chemical warfare agents. Should the coated materials be exposed to chemical agents, the agents and the coating can be rinsed off with a water wash. More than 99% of agent HD is removed from the coated substrate when rinsed with water, compared to less than 50% rinsing off of a similarly treated uncoated control. The coating is also particularly effective against G-agents, and does not hinder the oxidative detoxification of agent VX. The coating has been successfully packaged in both aerosol cans and unpressurized trigger sprayers; please contact the authors to obtain further information or samples.